

A method of making contact with a remote mobile user terminal (16) includes making a first attempt to contact the remote station using a first signal transmission from a satellite access node (12) via an earth orbiting satellite (14), the first transmission being of one of a plurality of different types, such as a voice, e-mail, short message, and the transmission being configured to achieve a first degree of penetration at the user terminal. If acknowledgement of receipt of the first contact attempt is not received, a second contact attempt (HPN) is made using a second signal transmission, to achieve a second, greater degree of penetration than the first signal transmission at the user terminal (16). The second signal transmission includes a short message related to the first contact attempt selected on the basis of the type of the first signal transmission. The short message of the second contact attempt is derived from a message centre HPNSC (24) and is selected depending on the type of the first transmission.

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## METHOD OF COMMUNICATION ESTABLISHING WITH A REMOTE USER

**Field of the invention**

The present invention relates to a communication method and apparatus,  
5 particularly for use in a mobile communication system.

**Background**

Terrestrial cellular communication systems are well-known in the art and a number of standards exist which define different signalling protocols for them,  
10 such as the GSM standard and the PCN standard. Details of these standards are given for example in "Mobile Radio Technology" by Gordon White, Butterworth Heinemann, 1994. The GSM and PCN systems are digital communication systems and allow paging and data communications in addition to voice communications. In the GSM system, a short message  
15 service (SMS) is provided for transmitting short messages to mobile terminals.

Mobile satellite communication systems have also been proposed in which radio frequency links are provided by a constellation of satellites. These satellite communication systems provide much greater coverage than terrestrial  
20 cellular systems. One example of such a system is the ICO™ system, aspects of which are described in patent publications WO 95/28747, WO 96/03814 and GB 2,295,296A. Other examples include the Inmarsat™ satellite system as described in "Satellite Communications : Principles and Applications" by Calcutt and Tetley, published 1994 by Edward Arnold, the Iridium™ satellite  
25 cellular system, described for example in EP-A-0365885, and the Odyssey™ system described for example in EP-A-0510789, EP-A-0575678 and EP-A-0648027.

However, in both terrestrial and satellite mobile communication systems, it is  
30 not always possible to communicate with a mobile user, since the received signal strength at the mobile user terminal may be severely attenuated, for example by blockage or multi-path fading. Furthermore, the gain of the user

terminal may be low, for example because the user terminal antenna is retracted or not deployed in the optimum position.

A satellite paging system is disclosed in US patent number 5,392,451 in which,  
5 if a call receiver does not acknowledge receipt of a paging message, the paging signal is repeated with a higher transmission power in order to achieve a higher degree of signal penetration at the user terminal.

#### Summary of the invention

10 The present invention provides an improved method of making contact with a user terminal which provides intelligible data to the user in the event of a failed contact attempt.

Broadly the invention provides a method of making contact with a remote  
15 user terminal, comprising making a first attempt to contact the remote station using a first signal transmission of one of a plurality of different types, the transmission being configured to achieve a first degree of penetration at the user terminal, and if acknowledgement of receipt of the first contact attempt is not received, making a second contact attempt using a second signal  
20 transmission, to achieve a second degree of penetration greater than the first degree of penetration at the user terminal, wherein the second signal transmission includes data related to the first contact attempt selected on the basis of the type of the first signal transmission.

25 The different types of first signal transmission may include: a short message from a message centre, and an incoming call from a subscriber station. For an incoming call, the different types of first signal transmission may include voice, facsimile or e-mail.

30 In accordance with another aspect of the present invention, the facilities for making the second contact attempt are provided as a message service centre, which can be added to an existing network, to upgrade its facilities.

In accordance with this aspect of the invention, there is provided telecommunications apparatus for making contact with a remote user terminal, comprising: a transmitter for transmitting telecommunications signals towards a remote terminal; a switching centre operative to route  
5 telecommunications signals of different types to the transmitter for transmission to the remote station, to attempt to contact the user terminal, with a first degree of penetration at the remote user terminal, and a message service centre for producing message signals to be routed to the transmitter for transmission to the remote station, to attempt to contact the user terminal,  
10 with a second degree of penetration greater than the first degree of penetration, at the remote user terminal.

#### **Brief description of the drawings**

Specific embodiments of the invention will now be described with reference  
15 to the accompanying drawings, in which:-

Figure 1 is a schematic diagram of a mobile satellite system network including a short message service centre, in an embodiment of the present invention;

Figure 2 is a sequence diagram of the transmission of an HPN signal following an unsuccessful attempt to deliver a short message in the network of Figure 1;

20 Figure 3 is a diagram of a high penetration channel frame format in the sequence of Figure 2;

Figure 4 is a schematic diagram of the user terminal in the network of Figure 1;

Figure 5 is a diagram showing the width of a high penetration message slot in  
25 the format of Figure 3 and of the active time windows necessary to receive the message;

Figure 6 is a diagram of the frequency signal acquisition window applied by the user terminal of Figure 4; and

Figure 7 is a schematic diagram of one of the satellites in the network of

30 Figure 1.

#### **Network**

Fig. 1 shows schematically part of a satellite communications network used for communication of short messages and high-penetration notification messages to a mobile user.

5 A fixed user 2 is connected to a public service telephone network (PSTN) 4. By dialling an appropriate number, the fixed user 2 is connected through the PSTN 4 to a short message service (SMS) service centre 6, which controls the sending of short messages to a mobile user by selecting the most appropriate network connection. By communicating with a home location register (HLR)  
10 8, the SMS service centre 6 is able to obtain location and customer profile information relating to the called mobile user.

The SMS service centre 6 is connected by appropriate communications links to one or more mobile communications networks which allow  
15 communication with mobile terminals. For example, the SMS service centre 6 may be connected both to a terrestrial cellular network conforming to the GSM standard and supporting the GSM short message service and to a mobile satellite system and may preferentially select the terrestrial cellular network when the mobile terminal is in range thereof.

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The SMS service centre 6 may also receive short message requests from mobile users, for example via a terrestrial cellular network or a mobile satellite system.

25 In Fig. 1, the SMS service centre 6 is connected to a mobile satellite system, such as the ICO<sup>TM</sup> system, which provides a messaging service including high penetration messaging. The mobile satellite system (MSS) 10 includes a plurality of satellite access nodes 12a, 12b which provide radio frequency communications links to a constellation of satellites 14a, 14b, 14c, at least  
30 some of which are in line-of-sight with a mobile user terminal 16 and enable wireless communications between one of the satellite access nodes 12 and the user terminal 16.

In one example described in GB 2,295,296A there are twelve satellite access nodes 12 located in optimal positions throughout the world. The satellite constellation comprises ten operational satellites in six-hour orbits in two orbital planes, each inclined at 45° to the equator. One spare satellite is provided in each plane. The arrangement of satellite access nodes 12 and satellites 14 provides a mobile satellite service with global coverage.

Alternative mobile satellite systems, such as the Iridium™, Inmarsat™ or Odyssey™ systems may be used.

Each satellite access node 12 includes a land earth LES 18a, 18b with multiple directional antennas which track some or all of the satellites 14 which are in view. Each satellite access node 12 also includes a mobile satellite switching centre (MSSC) 20 which routes communications traffic to other satellite access nodes and to gateways owned by third party operators who are authorised to access the mobile satellite system. The SMS service centre 6 is an example of one such gateway. Each MSSC 20 is connected to a visitor location register (VLR) 22, which comprises a database of details of user terminals 16 which are logged on to that satellite access node 12.

Information obtained from the HLR 8 identifies with which satellite access node 12 the user terminal 16 is registered and the SMS service centre 6 routes a message to the appropriate satellite access node 12 on the basis of that information. At that satellite access node 12, the mobile satellite switching centre 20 obtains more specific information from the VLR 22 to determine the location of the user terminal 16 more accurately and to determine to what type of message service the user terminal 16 has subscribed. This information determines how the satellite access node 12 will communicate with the user terminal 16, as discussed in more detail below.

#### High Penetration Notification

A high penetration notification service is controlled by a high penetration notification (HPN) service centre 24 which communicates with the MSSC 20

and with the LES 18 of each satellite access node 12.

A high penetration notification (HPN) is a message which is transmitted by one or more of the satellites 14 with a substantially higher link margin than is used for short messages, voice or data traffic. The link margin is defined as the excess signal energy to noise density ratio needed adequately to decode a message in a line-of-sight channel.

For example, normal voice and data channels achieve a lower penetration; they have sufficient link margin to be received by a hand-held user terminal in operational position with its antenna deployed, in direct line of sight to a satellite, or with light shadowing or fading. Short messages and control channels have sufficient link margin to be received by a handheld user terminal in a non-operational position, such as in a suitcase and/or with its antenna retracted and/or with medium/light radio shadowing or fading, i.e. medium penetration. A high penetration notification is used to send information to the user terminal 16 in situations where it may not be able to receive any other traffic, such as when the user terminal 16 is inside a building, in heavy radio shadowing or fading from any of the satellites 14 and with its antenna retracted. The link margin of a high penetration notification gives sufficient penetration to allow reception and decoding of data by the user terminal in these circumstances. For example, the link margin may be 28dB. The link margin is a function of the transmit power and may additionally be increased by coding, such as convolutional coding.

The HPN message delivered from the HPNSC 24 is selected depending on the type of contact attempt that was initially attempted, i.e. whether the first contact attempt was an attempt to deliver a short message, or to connect in incoming call to the user terminal, i.e. a mobile terminated call, and the type of incoming call, i.e. fax, voice, e-mail. The HPNSC 24 will deliver a HPN short message, and the configuration of the HPNSC 24 may be similar to a convention GSM SMS SC, such as the service centre 6, but dedicated to



provide the short messages used for the HPN service. Thus, the HPNSC 24 can be provided as a "bolt-on" item to upgrade an existing network without significant system architectural modification, in order to upgrade the network to provide an HPN service. Example of how the HPNSC 24 produces  
5 different messages to the user terminal 16 will now be described.

#### HPN after Short Message Failure

A first example of the use of a high penetration notification message will now be described with reference to Figures 1 and 2. At step 30, a message is  
10 transferred from the fixed user 2 to the SMS service centre 6. The message includes an identity code, such as a telephone number, which identifies the intended recipient, in this case the user terminal 16. At step 32, the SMS service centre 6 sends information identifying the user terminal 16 to the home location register 8, which replies with routing information such as the  
15 identity of the satellite access node 12 with which the user terminal 16 is registered. At step 34, the SMS service centre 6 forwards the message from the user 2 to the mobile satellite switching centre 20 of the satellite access node 12 identified by the home location register 8, together with information identifying the user terminal 16.

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At step 36, the mobile satellite switching centre 20 accesses the visitor location register 22, extracts therefrom detailed information on the location of the user terminal 16 and determines whether the owner of the user terminal 16 has subscribed to the short message service. At step 37, the message is sent to the  
25 LES 18 together with information relating to the expected location of the user terminal 16.

At step 38, the LES 18 selects a satellite which is likely to achieve transmission of the message to the user terminal 16 and selects a beam  
30 generated by that satellite 14 which covers the location of the user terminal 16 at that moment. The message is then sent via the selected satellite 14 to the user terminal 16.

The LES 18 detects whether any acknowledgement of the message is received from the user terminal 16 within a predetermined period t1. If no such acknowledgement is received, a failure signal is sent, at step 40, to the mobile satellite switching centre 20, which then sends, at step 42, a failure report to the SMS service centre 6, which may in turn send a failure report 44 to the fixed user 2. In response to the failure report at step 42, the SMS service centre 6 updates the HLR 8 to include the information that the user terminal 16 is currently not responding to short messages.

10 In response to the paging failure at step 40, the mobile satellite switching centre 20 forwards the message contents to the HPN service centre 24 in an HPN request, at step 48. The HPN service centre 24 then requests location information, together with other information needed for sending an HPN message, from the mobile satellite switching centre 20, at step 50. The mobile satellite switching centre 20 obtains the required information from the home location register 8 at step 52 and from the visitor location register 22 at step 54, and sends the required information to the LES 18 at step 56.

At step 58, the HPN service centre 24 generates an HPN message derived from the original message which was transferred at step 48, and the LES 18 sends the HPN message at step 60 to the user terminal 16. The process of sending the HPN message at step 60 will be described in more detail below.

When the user terminal 16 receives the HPN message, it sends an acknowledgement signal to the LES 18 at step 62. In response to this acknowledgement, the LES 18 signals to the HPN service centre 24 that the HPN has been acknowledged, at step 64, and thereby prevents further attempts by the HPN service centre 24 to send an HPN message derived from the same original message.

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#### HPN Incoming Call Alerting

Alternatively, the HPN message may be generated in response to failure to

deliver an incoming voice, fax, e-mail or data call to the user terminal 16.

The process for delivering such calls is similar to the process for delivering short messages, as described above, except that the call is routed from the PSTN 4 to a gateway mobile satellite switching centre (GMSSC) which routes the call to a selected satellite access node 12. The LES 18 sends a paging signal on a broadcast channel identifying the user terminal 16 to which the call is addressed. If no response is received from the user terminal 16 within a predetermined time and the subscriber profile of the user terminal 16 includes HPN supplementary service, the mobile satellite switching centre 20 forwards information relating to the call to the HPN service centre 24, in a similar manner to step 48 and the process continues as in the short message example described above, except that the HPN message contents do not contain a short message sent by a caller, but may instead contain information relating to the reason for the HPN request (e.g. failed incoming call) and/or the telephone number or identity of the caller. Repeated HPN requests resulting from further incoming calls from the same subscriber may be filtered out, as described below.

#### HPN Broadcast

The HPN message may be broadcast to more than one user terminal, for example to a defined user group or to all user terminals in a predefined area. HPN broadcasts are controlled by an HPN broadcast centre which communicates with each LES 18 in the same manner as the HPN service centre 24 or may form part of the HPN service centre 24. The HPN broadcast centre receives broadcast information from external information providers and controls the generation and scheduling of HPN broadcast messages.

No acknowledgement is required to HPN broadcast messages.

#### Diversity

Referring to Fig. 2, if no acknowledgement is received by the LES 18 at step

62, HPN service centre 24 commands the LES 18 to retransmit the HPN message after a predetermined short delay, for example in the next transmission phase cycle of the HPN channel. The delay may be determined according to the traffic load on the LES 18. Alternatively or additionally, the HPN message is re-sent by the LES 18 after a longer delay sufficient to allow the satellites 14 to move so that their direction from the user terminals 16 has changed significantly. The HPN message may then be repeated after the short delay.

- 10 If no acknowledgement is received from the user terminal 16 after a predetermined number of retransmissions of the HPN message, the HPN service centre 24 controls the LES 18 to retransmit the HPN message through another satellite 14 if the user terminal 16 has subscribed to this level of service. Although the user terminal 16 may not be able to receive an HPN message from the satellite 14a through which the HPN message was first transmitted, it may be able to receive the message through the second satellite 14b. The message is repeated a predetermined number of times, dependent on the traffic load, the priority of the message, and the subscription details of the user terminal 16, through the second satellite 14b until the LES 18 informs the HPN service centre 24 when an acknowledgement is received.

Optionally, if no acknowledgement is received from the user terminal 16 after a predetermined number of repeats when transmitting through the first or second satellite 14a or 14b or another satellite, the HPN service centre 24 routes the HPN message through an alternative one of the satellite access nodes 12b, for example for transmission through one of the satellites 14c which is in view of the user terminal 16. This may be required when the third satellite 14b is not in view of the first satellite access node 12a.

- 30 Any of the above diversity techniques may be used alone or may be combined in any sequence.

### HPN Filtering

The HPN service centre 24 detects whether an HPN request has occurred for the same reason as a previous HPN request, by comparing the contents of the HPN request with a database of previously received HPN requests. For  
5 example if the short message content and subscriber identity is the same as those of a previously received HPN request, this indicates that either the fixed user 2 or the SMS service centre 6 attempted to repeat the same short message. If the HPN request resulted from incoming call failure, then the HPN service centre detects whether a previous HPN request has already been received  
10 relating to a call attempt from the same user 2 to the same user terminal 16.

In either case, the repeated HPN request is ignored by the HPN service centre 24. Alternatively, the repeated HPN request may be ignored only if the number of repeated requests exceeds a predetermined number.

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### HPN Request Contents

The HPN request sent to the HPN service centre 24 at step 48 includes the following information:

1. Identification of the subscriber to which the short message is directed,  
20 which may be of the same format as the IMSI (International Mobile Subscriber Identity) and the TMSI (Temporary Mobile Subscriber Identity) defined in GSM Technical specification 03.03. The TMSI is allocated by the VLR 22 when the user terminal 6 registers at the corresponding LES 18.
- 25 2. The mobile station international ISDN number, which may be of the same format as the GSM MSISDN.
3. The HPN subscription details of the subscriber, such as the priority to be assigned to the HPN message. Preferably, there are only two levels of priority: standard and high.
- 30 4. Location information relating to the user terminal 6, such as latitude, longitude, location area identification or cell global identification.
5. Information relating to the reason for the HPN request, such as failed

short message or incoming call, and the type of service that triggered the HPN request, such as voice, facsimile or short message service.

6. Additional information for compiling the HPN message. For example, if the HPN request resulted from a short message failure, the additional information includes the header and content of the original short message.

#### HPN Message Contents

The HPN service centre 24 receives the original message and may derive the contents of the HPN message from the original message or may generate an HPN message independently of the content of the original message. For example, the HPN service centre 24 may discard the content of the message and generate a simple notification signal as the HPN message. In this case, the HPN message indicates simply to the user terminal 16 that an attempt has been made to communicate with it. Alternatively, the HPN message may consist of the telephone number of the fixed user 2, a truncated version of the original message or a user message tag which indicates one of a set of messages previously stored at the user terminal 16 (e.g. "I'm on the next train home").

#### HPN Message Burst

The HPN message is transmitted by the LES 18 in a message burst, consisting of a synchronisation preamble, system and satellite information, message data and error check data. The satellite information includes a code identifying the satellite used to transmit the HPN message.

The system information block may further include an acknowledgement channel frequency reference and an acknowledgement channel time delay reference, which informs the user terminal 16 which frequency to use for sending the acknowledgement signal, at step 62, and how long to delay before sending the acknowledgement.

#### HPN Transmission Channel

The timing of the HPN transmission channel, as transmitted by one of the satellites 14, is shown in Figure 3. The high-penetration message bursts HP are interleaved with broadcast channel bursts (BCCH). Each high penetration message burst comprises a data slot preceded by a synchronisation preamble  
5 burst F which provides a frequency and timing reference.

The timing of the broadcast channel and high penetration slots shown in Figure 3 is referenced with respect to the satellite, so that the satellite is never required to transmit both broadcast channel and high penetration bursts at the  
10 same time. In this way, the peak power requirement of the satellite is kept below a defined limit, and power fluctuations in the satellite are avoided.

The user terminal 16 receives the system and satellite information and records the arrival time of the message burst. From this information, the user  
15 terminal 16 synchronises its own transmit and receive burst timing with that of the system.

#### HPN Message Types

The message burst contents further include a temporary user ID which  
20 identifies the user for which the message is intended, and a message ID which includes a message reference ID and a message type ID identifying the type of message to be sent.

The data slot D may contain a whole message or part of a longer message. In  
25 the latter case, the message contents of a series of data slots D addressed to the user terminal 16 are concatenated by the user terminal 16 to reconstruct the original message.

The message contents may be encrypted or scrambled so that only the user  
30 identified by the temporary ID is able to decode the message.

The message contents may be encoded so as to increase the effective link

margin, for example by means of convolutional coding.

#### User Terminal

The operation of the user terminal 16, when receiving an HPN signal, will now be described with reference to Figure 4. The user terminal comprises a receiver 70, which demodulates RF signals received from an antenna 72 and sends the demodulated signals to a controller 74. The controller 74 sends signals, such as the acknowledge signal of step 62, to a transmitter 76, which RF modulates the signal and outputs the RF modulated signal to the antenna 72 so that it is transmitted.

The controller 74 controls the frequency and timing of the receiver 70 and transmitter 76. The controller 74 includes a clock from which the receive and transmit timings are determined. The clock is driven by an oscillator 78. Messages received by the receiver 70 are stored in a memory 79 and can be displayed on a display 80, such as an LCD screen. The user controls the operation of the user terminal 16 by means of a key pad 82, so as to retrieve, display and clear messages. The memory 79 also stores a look-up table of messages which are identified by received message tags.

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The user terminal 16 may also include a microphone, earpiece, analog-to-digital and digital-to-analog convertors and a codec so that it can be used as a mobile telephone. Alternatively, if the user terminal 16 is configured as a pager only, these additional parts may be omitted.

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#### Sleep Mode

When the user terminal 16 is on standby and is not being used for voice or data calls, the controller 74 is normally in "sleep" mode in which the receiver 70 is switched off in order to conserve power, but periodically, determined by its clock, the controller 74 switches into an active mode in which the receiver 70 is switched on in order to be able to receive signals. The controller 74 is normally synchronised with the mobile satellite system 10 so that it switches

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into active mode in synchronism with the arrival time of message bursts.

As shown in Figure 5, a slot window S is the period during which the receiver 70 must be active to receive the data slot D. An active window W, during which the controller 74 is in the active mode, is wider than the slot window S to accommodate the maximum change in propagation delay (the difference between the transmitting satellite being at minimum elevation above the horizon and being directly overhead).

10 However, if the user terminal 16 is out of contact with the mobile satellite system 10 for an extended period, controller 74 gradually loses synchronisation with the mobile satellite system 10 as a result of the limited accuracy of the oscillator 78 and uncertainties in the propagation time of signals from the satellites 14. The controller 74 increases the active time window as the period of being out of contact increases in order to allow for these uncertainties, for example to an extended time window W', but this increases the active duty cycle of the user terminal 16 and hence its power consumption. When the user terminal 16 receives an HPN message burst, the controller 74 synchronises its clock with the mobile satellite system 10 and  
20 can then reduce the size of its active time window back to the original time window W.

Likewise, the frequency signal acquisition window of the user terminal 16 increases as the duration since the last burst was received increases. As shown  
25 in Figure 6, the controller 74 expects to receive the next message burst at frequency  $f_0$ . The transmitted signal is Doppler compensated to the beam centre, but there will be a degree of uncertainty in the Doppler shift as a result of the position of the user terminal 16 in the beam relative to the beam centre. Hence, the controller 74 must set a minimum frequency acquisition  
30 window  $\Delta f$  around  $f_0$  to take account of the Doppler uncertainty.

Moreover, the uncertainty due to drift in the oscillator frequency of the

receiver 70 increases with time since the last message burst was received. Hence, the width of the frequency acquisition window is increased by the controller 74, for example to an extended frequency acquisition window  $\Delta f'$ , until the next burst is received and the frequency acquisition window can be  
5 reduced to the original minimum width  $\Delta f$  by determining the reference frequency of the preamble burst F.

#### Re-Registration

If the user terminal 16 receives a message which carries its user ID, this  
10 indicates that an attempt has been made to establish contact with the user terminal 16, for example to deliver a short message. The user terminal 16 continues to monitor the broadcast channel BCCH broadcast by a satellite 14 until it is able to receive this channel with sufficient quality. The user terminal 16 then sends a re-registration signal to the LES 18, indicating that  
15 the user terminal 16 is now able to access the network.

The LES 18 determines from the re-registration request the current location of the terminal, for example by measuring the time delay and Doppler shift of the re-registration signal as received through the satellite 14, and updates the  
20 visitor location register 22 to record the user's current location.

If the HPN message was sent in response to a failed short message, the mobile satellite switching centre 20 then sends the original short message to the LES 18 for transmission to the user terminal 16 over a short message service  
25 channel, with a lower link margin than is used for the HPN burst.

If the HPN message was sent in response to the failure of an incoming call, the user terminal 16 may display to the user the caller identity which was sent in the HPN message and the type of service which caused the HPN message  
30 and may allow the user to call back the unsuccessful caller. For example, if the caller identity includes the telephone number of the calling party, the user terminal 16 displays the telephone number on the display 80 and the user

need only press an "enter" or similar key on the key pad 82 to call back the unsuccessful caller. Alternatively, the GMSSC may attempt to re-establish the original call by calling both the calling party 2 and the user terminal 16 in turn and connecting them together.

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HPN messages are also generated automatically at the mobile satellite switching centre 20 in response to prompts other than a failed short message transmission, or incoming call. For example, the mobile satellite switching centre 20 determines from the visitor location register 22 which user terminals  
10 have not been in contact with the mobile satellite system 10 for more than a predetermined length of time, and generates re-registration request HPN messages addressed to those user terminals. In response to receipt of the re-registration request HPN messages, the user terminals send re-registration requests to the LES 18 when they are able to receive registration channels. In  
15 this way, the locations of the user terminals logged on to the satellite access node 12 can be updated from time to time.

### Satellite

The transmission power of the satellites 14 is limited by the power which is  
20 available from their solar arrays and from battery storage when the satellite 14 is in the earth's shadow. The high penetration notification bursts consume a significant proportion, as much as 20%, of the total transmit power of the satellite 14. Therefore, each satellite 14 provides only one HPN transponder which is shared among the LESs 18 and among the transmit beams of the  
25 satellite 14.

As shown in Figure 7, each satellite 14 has a feeder link communication subsystem 100, which transmits and receives communications channels through a feeder link with the LES 18, by means of a feeder link antenna 98.  
30 The feeder link antenna 98 generates a broad beam covering substantially all of the earth's surface within the field of view of the satellite 14, so as to receive signals from any one of the satellite access nodes 12 within the field of

view. The feeder link communications subsystem 100 is connected via a channel processing subsystem 102 to a mobile communications subsystem 104, which controls a multi-beam antenna array 106. The mobile communication subsystem 104 and multi-beam antenna 106 generate an overlapping array of spot beams over the coverage area of the satellite 14, which provide user links to mobile user terminals.

The channel processing subsystem 102 maps feeder link channels onto mobile link channels in the spot beams generated by the mobile communication subsystem 104 according to a resource management system 105, including a channel assignment table which can be modified by signals received from the LES 18 via a telemetry, tracking and control (TT&C) subsystem 107 of the satellite 14. The TT&C subsystem 107 receives channel assignment information from one or more of the LESs 18 by means of a TT&C antenna 108.

Details of an example of the satellite communication system are given in patent publication number WO95/28747.

The output of the HPN transponder is connected to only one of the beams of the multibeam antenna 106 at any one time, as a result of the limit on the instantaneous power of the HPN message burst. The beam to which the HPN transponder is connected can be selected for each HPN message burst, as will now be described.

The feeder link communication subsystem 100 allocates a dedicated frequency channel in the feeder link to HPN message bursts. The channel assignment table 105 comprises a data store storing a set of data triplets representing the beam assignment, the mobile link frequency assignment and the transponder gain for the HPN transponder. At a predetermined time before an LES 18 sends an HPN message burst, the LES 18 transmits to the TT&C subsystem 107 a selection command which identifies one of the data triplets in the

channel assignment table. That data triplet determines in which beam, at what frequency, and with what gain the subsequent HPN message burst will be transmitted. The resource management subsystem 105 controls the channel processing subsystem 102 to allocate the indicated beam, frequency and gain  
5 to the HPN transponder after a predetermined interval from the reception of the selection command, in synchronism with the reception of the subsequent HPN message burst so that the HPN message burst is transmitted with that allocation.

10 In this way, the HPN transponder can be assigned to any one of the spot beams, under control of any one of the LESs 18 within view of the satellite 14.

#### HPN Scheduling

15 Since each of the LESs 18 within the line of sight of the satellite 14 is able to send an HPN message to that satellite 14 and is able to control the beam assignment for that message, negotiation between satellite access nodes 12 is required so as to schedule the HPN resource between the satellite access nodes 12.

20

The satellite access nodes 12 are interconnected by a network, such as described in GB 2 295 296A. The network may comprise telephone or ISDN lines, proprietary lines or any other type of connection which allows reliable communications between the satellite access nodes 12. The satellite access  
25 nodes 12 also communicate with each other via the C-to-C band links provided by the satellites 14.

At predetermined intervals, for example every five to ten seconds, each satellite access node 12 transmits to each of the other satellite access nodes 12  
30 information on the queued messages which that satellite access node 12 is ready to send. The information includes the location of the intended recipient user terminal, the frequency channel and time slot to be used in the

mobile link, the length of the message and the priority assigned to it. Each of the satellite access nodes 12 compiles data on all of the queued messages waiting to be transmitted at any of the satellite access nodes 12.

- 5 Each satellite access node 12 applies the same scheduling algorithm to the compiled list of messages to determine the order in which the messages should be sent in the feeder link HPN channel. Since the same algorithm is applied to the same data at each satellite access node 12, the same decision is made at each satellite access node 12 on the order in which HPN messages are sent in  
10 the dedicated feeder link channel and the HPN burst can be transmitted by the LESs 18 to each satellite 14 without collision in the feeder link channel. The scheduling algorithm also determines the frequency and time slot assigned to the user terminal 16 for acknowledgement, so as to avoid collision between acknowledgement signals from user terminals 16.

- 15 Any messages which are not acknowledged by the respective user terminal 16 are kept in the queue of messages at each satellite access node 12 and will be included in the next list of messages sent to the other satellite access nodes 12.

- 20 Since the HPN message burst provides synchronisation information to all user terminals 16 within the coverage area of a spot beam, it is preferred that an HPN burst should be transmitted in each spot beam at intervals less than a predetermined maximum. The algorithm used by the satellite access nodes 12 determines the ordering of the messages in accordance with the spot beam to  
25 which the messages will be delivered, so as to ensure that all of the spot beams are allocated at least one HPN message within the maximum interval. If required, dummy messages are added to the message queue at one of the satellite access nodes to ensure that this criterion is satisfied. If no HPN messages are assigned to any time slot, a dummy message is added to fill that  
30 time slot, so as to avoid power fluctuations in the satellite.

While the above embodiments have been described with reference to a mobile

satellite communications system, aspects of the invention are also applicable to terrestrial cellular and non-cellular mobile communications systems.

The apparatus of the communications system is described in terms of functional blocks. However, the skilled person will appreciate that the blocks do not necessarily represent discrete physical units but instead the functions of several blocks may be integrated or a single function may be distributed among discrete units.

10 The above embodiment uses a TDMA channel format to separate message bursts in the HPN channel. However, the scheduling algorithm may also be applied to other multiple access formats, such as CDMA or spread spectrum TDMA. For example, the scheduling algorithm may determine the spread-spectrum code to be used for each message.

15 Preferably, the HLR 8 and the VLR 22 comprise HLR and VLR apparatus based on designs for use with a GSM system, to allow the use of off-the-shelf components and reduce development costs. Alternatively, equipment specifically developed for a mobile satellite system or a non-GSM terrestrial  
20 system may be used.

References to mobile user terminals will be understood to include hand-held terminals, vehicle-mounted terminals including aeronautical and marine terminals, and temporary or permanent installations such as wireless telephone  
25 booths or stations or telephone networks connected to a wireless communications link.

Aspects of the present invention may be applied to mobile satellite systems such as the proposed Iridium™ and Odyssey™ systems.

30

It will be understood that components of embodiments of the invention may be located in different jurisdictions or in space. For the avoidance of doubt,

the scope of the protection of the following claims extends to any part of a telecommunications apparatus or system or any method performed by such a part, which contributes to the performance of the inventive concept as defined in the claims.



## Claims

1. A method of making contact with a remote user terminal, comprising making a first attempt to contact the remote station using a first signal transmission of one of a plurality of different types, the transmission being configured to achieve a first degree of penetration at the user terminal, and if acknowledgement of receipt of the first contact attempt is not received, making a second contact attempt using a second signal transmission, to achieve a second degree of penetration greater than the first degree of penetration at the user terminal,  
wherein the second signal transmission includes data related to the first contact attempt selected on the basis of the type of the first signal transmission.
2. A method according to claim 1 wherein the different types of first signal transmission include: a short message from a message centre, and an incoming call from a subscriber station.
3. A method according to claim 2 wherein the different transmission types include, for the incoming call, voice, facsimile or e-mail.
4. A method according to any preceding claim including selecting the data for the second signal transmission to include a message for alerting the user terminal that the first contact attempt has been made.
5. A method according to any preceding claim including selecting the data for the second transmission to include a short message determined in dependence on the type of the first signal transmission.
6. A method according to claim 5 including, when the first signal transmission comprises a short message, selecting the data for the second signal transmission to include the short message from the first transmission.

7. A method according to claim 5 including, when the first signal transmission comprises a short message, selecting the data for the second signal transmission to include a truncated version of the short message from the first transmission.

5

8. A method according to any preceding claim including selecting the data for the second transmission to include the identity of the subscriber making the first call attempt.

9. A method according to any preceding claim including routing signals for the first contact attempt through a switching centre to a transmission station for onward transmission to the remote user terminal; seeking an acknowledgement of receipt of the first call attempt by the user terminal; and in the event that no acknowledgement is received, instructing a service centre  
15 to provide a message for use in said second transmission on the basis of information received from the switching centre concerning the type of signal transmission for the failed first contact attempt, and forwarding the message from the service centre to the transmission station for onward transmission in said second signal transmission to the user terminal.

20

10. A method according to claim 9 including instructing a location register that contains information about the location of the remote user terminal, to provide routing information for routing the second contact attempt to the terminal.

25

11. A method according to claim 9 wherein the remote user terminal transmits a re-registration attempt in response to successful receipt of the second contact attempt, the method including updating the location information in the location register, in response to the re-registration attempt.

30

12. A method according to claim 11 including routing a message intended for the remote user terminal, after a successful second contact attempt,

utilising the updated location information from the location register in a signal transmission for achieving a degree of penetration at the remote terminal which is less than the second degree of penetration.

- 5 13. A method according to claim 11 or 12 including regularly making attempts to contact a plurality of said remote terminals using signal transmissions for achieving said second degree of penetration at the remote stations, for stimulating re-registration attempts thereby, and updating the location information in the location register in response to the re-registration  
10 attempts from the remote terminals.

14. A method according to any preceding claim wherein the transmissions are directed towards at least one earth orbiting satellite and include instructions for controlling the satellite to retransmit them at power levels for  
15 achieving said respective degrees of penetration at the user terminal.

15. A method according to any preceding claim including repeating the second contact attempt if no acknowledgement of the first contact attempt is received from the user terminal.

20

16. A method according to claim 15 including causing the repetition of the second contact attempt to be transmitted along a different route to the remote user terminal, from the route taken by the first occurrence of the second contact attempt.

25

17. A method according to claim 16 including routing successive transmissions of the second contact attempt, from a common earth station towards different earth orbiting satellites.

- 30 18. A method according to claim 16 including routing the successive transmissions towards an earth orbiting satellite constellation from different earth stations.

19. Telecommunications apparatus for making contact with a remote user terminal, comprising

a transmission station operative to make a first attempt to contact the remote user terminal, with a first signal transmission of one of a plurality of different types, the transmission being configured to achieve a first degree of penetration at the remote user terminal, and if acknowledgement of receipt of the first contact attempt is not received, to make a second contact attempt with a second signal transmission, to achieve a second degree of penetration greater than the first degree of penetration, at the user terminal,

wherein the second signal transmission includes data related to the first contact attempt selected on the basis of the type of the first signal transmission.

20. Apparatus according to claim 9 wherein the different types of first signal transmission include: a short message from a message centre, and an incoming call from a subscriber station.

21. Apparatus according to claim 10 wherein the incoming call comprises voice, facsimile or e-mail.

22. Apparatus according to any one of claims 19 to 21 including:

a transmitter for transmitting the first and second signal transmissions towards the remote user terminal,

a switching centre for routing signals for the first transmission to the transmitter, and

a service centre for producing the data for the second signal transmission, if no acknowledgement of the first transmission is received from the user terminal.

23. Apparatus according to claim 22 including a receiver for receiving acknowledgement signals from the remote user terminal, the switching centre being operative to request the service centre to produce the data for the

second signal transmission, if no acknowledgement of the first transmission is received by the receiver within a predetermined time following the first signal transmission.

5 24. Apparatus according to claim 22 or 23 including a location register for maintaining a record of the location of the remote user terminal, the location register being operative to provide data for routing the second signal transmission to the user terminal.

10 25. Apparatus according to claim 24 wherein the location register comprises a visitor location register for roaming, remote user terminals.

26. Apparatus according to claim 24 or 25 wherein the location register comprises a home location register for the user terminal.

15

27. Apparatus according to claim 24, 25 or 26 wherein the service centre is operative to request routing information for the second signal transmission, derived from the location register.

20 28. Apparatus according to claim 27 wherein the service centre is operative to request the routing information by sending a request to the switching centre, which requests the information from the location register such that it is forwarded to the transmitter.

25 29. Apparatus according to any one of claims 24 to 28 wherein the remote user terminal is operative to transmit a re-registration attempt in response to successful receipt of the second contact attempt, the transmission station being operative to update the location information in the location register, in response to the re-registration attempt.

30

30. Apparatus according to claim 29 wherein the transmitter is operative to transmit a message intended for the remote user terminal, after a successful

second contact attempt, utilising the updated location information from the location register, in a signal transmission for achieving a degree of penetration at the remote terminal which is less than the second degree of penetration.

5 31. Apparatus according to claim 29 or 30 wherein the transmitter is operative to make regular attempts to contact a plurality of said remote user terminals using signal transmissions for achieving said second degree of penetration at the remote stations, for stimulating re-registration attempts thereby, and to update the location information in the location register in  
10 response to the re-registration attempts from the remote terminals.

32. Apparatus according to any one of claims 22 to 31 wherein the switching centre includes an input to receive incoming short messages from a remote short message centre, for use in the first contact attempt.

15

33. Apparatus according to any one of claims 22 to 31 wherein the switching centre includes an input to receive incoming calls from a remote subscriber, for use in the first contact attempt.

20 34. Apparatus according to any one of claims 22 to 33 wherein the transmitter comprises a land earth station for transmitting the first and second signal transmissions towards an earth orbiting telecommunications satellite.

35. Apparatus according to any one of claims 22 to 33 wherein the service  
25 centre is operative to select the data for the second signal transmission to include a message to alert the remote user terminal that the first contact attempt has been made.

36. Apparatus according to any one of claims 22 to 33 wherein the service  
30 centre is operative to select the data for the second transmission to include a short message determined in dependence on the type of the first signal transmission.

37. Apparatus according to claim 36 wherein the data for the second signal transmission includes a short message from the first transmission.

38. Apparatus according to claim 37 wherein the data for the second transmission include a truncated version of the short message from the first transmission.

39. Apparatus according to any one of claims 22 to 38 wherein the service centre is operative to select the data for the second transmission to include the identity of the subscriber making the first call attempt.

40. Apparatus according to any one of claims 19 to 39 wherein the transmission station is operative to direct said transmissions towards at least one earth orbiting satellite, and said transmissions include instructions for controlling the satellite to retransmit the transmissions received thereby at power levels for achieving said respective degrees of penetration at the remote user terminal.

41. Apparatus according to any one of claims 19 to 40 wherein the transmission station is operative to repeat the second contact attempt if no acknowledgement of the first contact attempt is received from the remote user terminal.

42. Apparatus according to claim 41 wherein the transmission station is configured to provide diversity between the second contact attempts.

43. Apparatus according to claim 41 or 42 wherein the repetition of the second contact attempt is transmitted along a different route to the remote user terminal, from the route taken by the first occurrence of the second contact attempt.

44. Apparatus according to claim 41, 42 or 43 wherein successive transmissions of the second contact attempt are routed from a common earth

station towards different earth orbiting satellites.

45. Apparatus according to claim 41, 42 or 43 wherein the successive transmissions are routed towards an earth orbiting satellite constellation from  
5 different earth stations.

46. A method of responding, at a user terminal, to attempted contact from at least one remote transmission station, wherein a first contact attempt includes a first signal transmission of one of a plurality of different types, the  
10 transmission being configured to achieve a first degree of penetration at the user terminal, and a second contact attempt includes a second signal transmission configured to achieve a second degree of penetration greater than the first degree of penetration at the user terminal, the second signal transmission including data related to the first contact attempt selected on the  
15 basis of the type of the first signal transmission, the method comprising the steps of:

attempting to receive the contact attempts, and in the event that the second but not the first contact attempt is discernibly received, providing a user discernible manifestation of the data transmitted in the second attempt.

20

47. A method according to claim 46 including providing a visual display at the user terminal based on said data in the second signal transmission.

48. A method according to claim 47 wherein the display comprises a short  
25 message.

49. A method according to claim 48 wherein the displayed short message indicates the type of transmission that failed to reach the user terminal in the first contact attempt.

30

50. A method according to claim 47 wherein the display comprises a calling line identity.



51. A method according to claim 46, wherein, when the first contact comprised a short message, subsequently transmitting the short message to achieve a degree of penetration less than the second level.
52. A method according to any one of claims 46 to 51 wherein the second signal transmissions are transmitted in periods of a regular temporal pattern, and including switching the user terminal from a sleep mode to an active mode for periods corresponding to those of the temporal pattern.
53. A method according to claim 52 wherein the temporal pattern includes transmissions to achieve said second level for a plurality of different user terminals.
54. A method according to claim 52 or 53 including progressively increasing the length of the active mode periods until a signal transmission is received.
55. A method according to claim 51, 52 or 53 wherein the signal transmissions are each of a predetermined frequency, and the user terminal has frequency acquisition window for the signal transmissions, the method including progressively increasing the width of the frequency acquisition window until a signal transmission is received.
56. A user terminal configured to perform the method claimed in any one of claims 46 to 55.
57. A user terminal as claimed in claim 56, comprising a mobile telephone handset.
58. Telecommunications apparatus for making contact with a remote user terminal, comprising:  
a transmitter for transmitting for transmitting

telecommunications signals towards a remote terminal;

a switching centre operative to route telecommunications signals of different types to the transmitter for transmission to the remote station, to attempt to contact the user terminal, with a first degree of penetration at the remote user terminal, and

a message service centre (24) for producing message signals to be routed to the transmitter for transmission to the remote station, to attempt to contact the user terminal, with a second degree of penetration greater than the first degree of penetration, at the remote user terminal.

10

59. Apparatus according to claim 58 wherein the different types of first signal transmission include: a short message from a message centre, and an incoming call from a subscriber station.

15 60. Apparatus according to claim 59 wherein the incoming call comprises voice, facsimile or e-mail.

61. Apparatus according to any one of claims 58 to 60 including a location register for maintaining a record of the location of the remote user terminal, the location register being operative to provide data for routing the contact attempt to achieve the second degree of penetration at the user terminal.

20

62. Apparatus according to claim 61 wherein the location register comprises a visitor location register for roaming, remote user terminals.

25

63. Apparatus according to claim 61 wherein the location register comprises a home location register for the user terminal.

64. Apparatus according to claim 61, 62 or 63 wherein the service centre is operative to request routing information from the location register, for the contact attempt with the second degree of penetration.

30

65. Apparatus according to claim 61, 62, 63 or 64 wherein the service centre is operative to request the routing information by sending a request to the switching centre, which requests the information from the location register such that it is forwarded to the transmitter.

5

66. Apparatus according to any one of claims 58 to 65 including a receiver for receiving acknowledgement signals from the remote user terminal in response to a first contact attempt for achieving said first degree of penetration, the switching centre being operative to request the service centre  
10 to produce the signals for making a second contact attempt with the user terminal with said second degree of penetration, if no acknowledgement of the first transmission is received by the receiver within a predetermined time following the first attempt.

15 67. Apparatus according to claim 66 wherein the remote user terminal is operative to transmit a re-registration attempt in response to successful receipt of the second contact attempt, the transmission station being operative to update the location information in the location register, in response to the re-registration attempt.

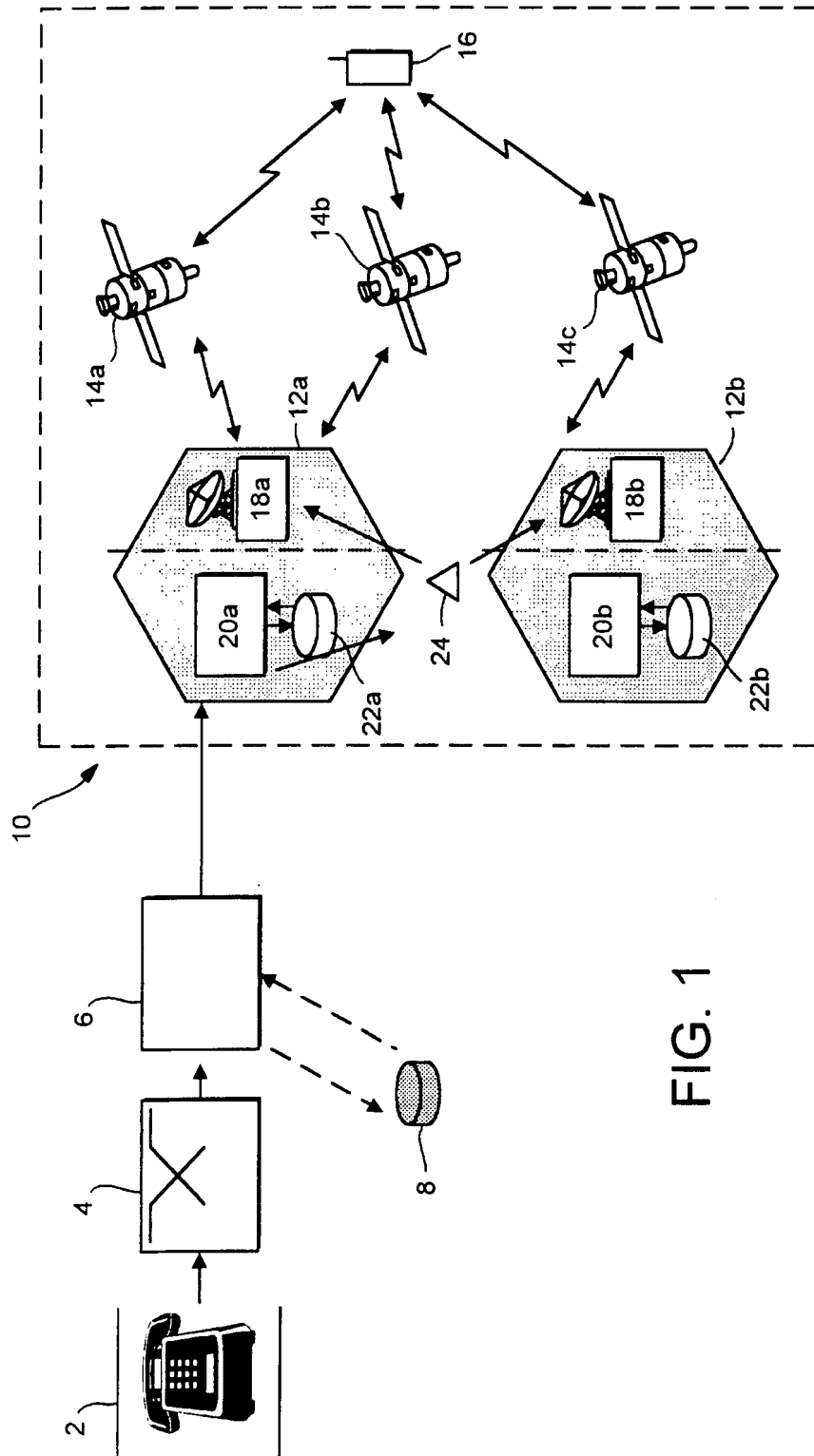
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68. Apparatus according to claim 66 wherein the transmitter is operative to send a message intended for the remote user terminal, after a successful second contact attempt, utilising the updated location information from the location register, in a signal transmission for achieving a degree of penetration at the  
25 remote terminal which is less than the second degree of penetration.

69. Apparatus according to claim 61, 62 or 63 wherein the transmitter is operative to make regular attempts to contact a plurality of said remote user terminals using signal transmissions for achieving said second degree of  
30 penetration at the remote stations, for stimulating re-registration attempts thereby, and to update the location information in the location register in response to the re-registration attempts from the remote terminals.

70. Apparatus according to any one of claims 58 to 69 wherein the transmitter comprises a land earth station for transmitting the first and second signal transmissions towards an earth orbiting telecommunications satellite.
- 5 71. Apparatus according to any one of claims 58 to 69 wherein the service centre is operative to provide signals for the contact attempt with said second degree of penetration, to include a message to alert the remote user terminal that a contact attempt has been made at said first degree of penetration.
- 10 72. Apparatus according to claim 71 wherein the message comprises a short message.
73. A method of making contact with a remote user terminal, comprising routing telecommunications signal of different types through a  
15 switching centre to a transmitter for transmission to the remote station, to attempt to make contact with the user terminal, with a first degree of penetration at the remote user terminal,  
providing from a short message service centre, signals that are routed to the transmitter for transmission to the remote station, to attempt to make  
20 contact with the user terminal, with a second degree of penetration greater than the first degree of penetration, at the remote user terminal.
74. A method according to claim 16 including seeking acknowledgement signals from the remote user terminal in response to a first contact attempt for  
25 achieving said first degree of penetration, and requesting the service centre to produce the signals for making a second contact attempt with the user terminal with said second degree of penetration, if no acknowledgement of the first contact attempt is received within a predetermined time following the first attempt.

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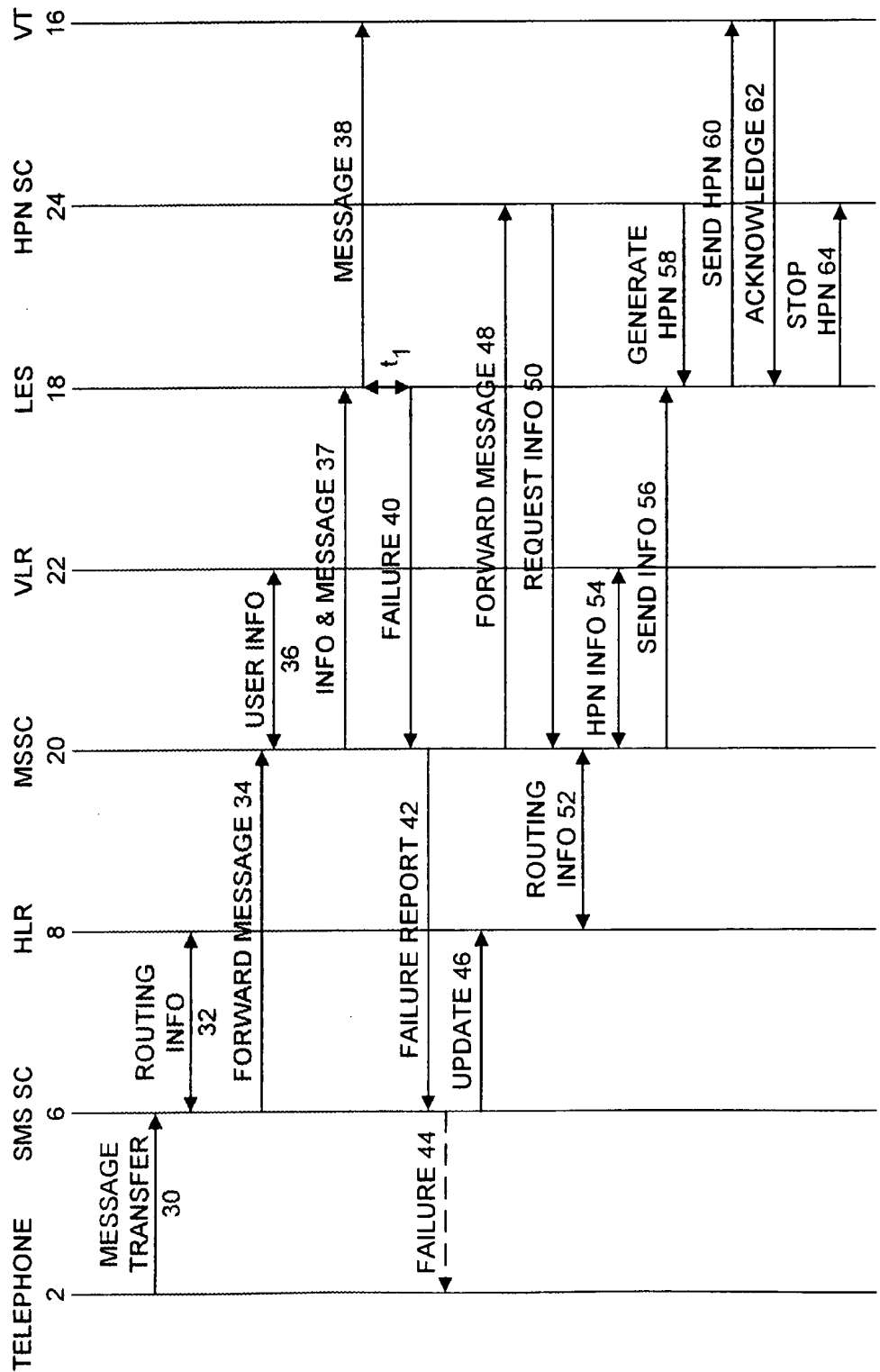


FIG. 2

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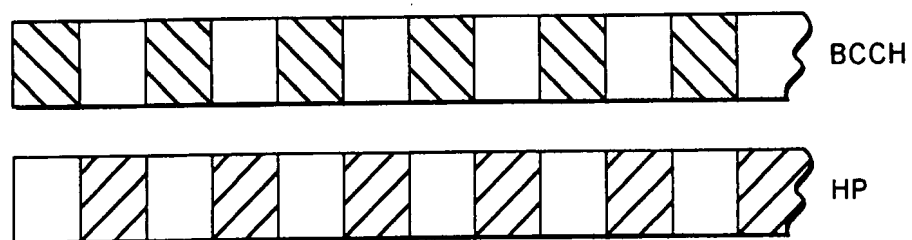


FIG. 3

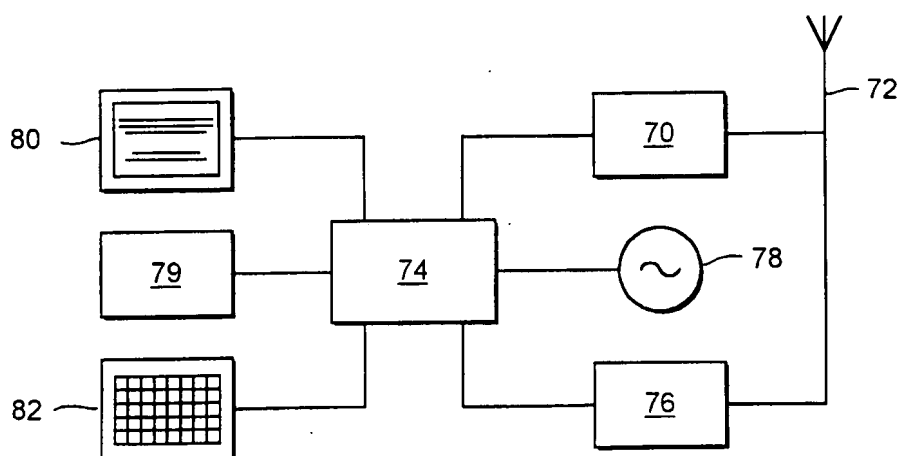


FIG. 4

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FIG. 5

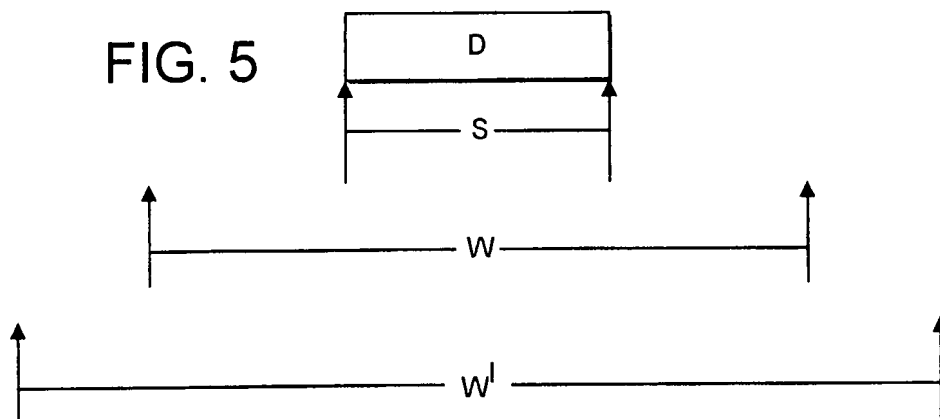


FIG. 6

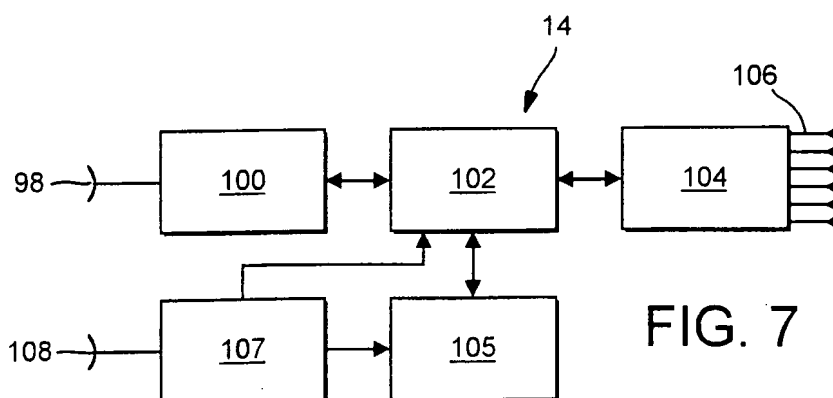
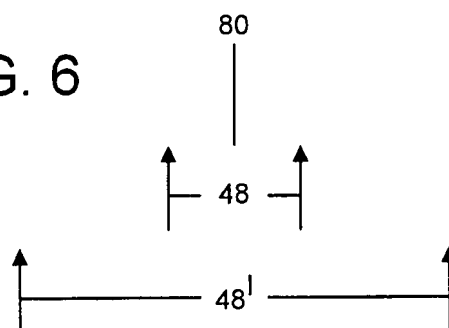


FIG. 7



# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 97/02328

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 H04B7/185 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 08941 A (ERICSSON) 21 March 1996  see page 3, line 19 - page 4, line 4; figures 2,3,6 ---	1,4,9, 11-13, 15,19, 22,23, 46,58, 61-66, 73,74
A	EP 0 533 509 A (NTT) 24 March 1993  see claims 1-4; figures 4,5 ---	1,4,9, 11-13, 15,19, 22,23, 46,58, 61-66, 73,74
-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance  
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  
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Date of the actual completion of the international search

18 December 1997

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# INTERNATIONAL SEARCH REPORT

Inter. Patent Application No

PCT/GB 97/02328

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 684 746 A (SIEMENS) 29 November 1995  see claim 1 ---	2,5,6, 20,32, 36-38, 48,49, 51,59,72
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A	WO 96 21332 A (ERICSSON) 11 July 1996  see page 3, line 18 - page 4, line 16; figures 1-7 ---	10,14, 24-26, 29-31, 34,39, 40,44, 45,67-71
A	US 5 430 729 A (RAHNEMA) 4 July 1995  see column 2, line 55 - column 3, line 60; figures 8-10 -----	16-18, 27-29, 33,35, 41-43, 45,47, 50,52-56

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information on patent family members

Inter. Application No

PCT/GB 97/02328

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